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THE THEORY OF THE ORIGIN OF THE ROTATION OF STARS AND PLANETS

ТЕОРІЯ ПОХОДЖЕННЯ ОБЕРТАННЯ ЗІРОК ТА ПЛАНЕТ

Summary. *The reason for the rotation of stars and planets has not yet found a clear answer. The modern idea of gravitational collapse does not allow to reveal the essence of the process. Meanwhile, the importance of the raised problem is undeniable, because it reveals the foundations of the Universe. The article attempts to develop a theoretical basis for the cause of rotation of stars and planets. The theory is based on the law of conservation of energy. The scheme of initialisation of matter rotation under the influence of gravitational forces is proposed. Analytical dependences describing the process are deduced. The conclusions of the theory are compared with the existing experimental knowledge.*

Key words: *stellar rotation, planetary rotation, energy source of stellar rotation.*

Анотація. *Причина обертання зірок і планет досі не знайшла однозначної відповіді. Сучасне уявлення про гравітаційний колапс не дозволяє розкрити суть процесу. Водночас важливість порушеної проблеми незаперечна, оскільки вона розкриває основи Всесвіту. У статті* *зроблено спробу розробити теоретичні основи причини обертання зірок і планет. Теорія заснована на законі збереження енергії. Запропоновано схему ініціалізації обертання матерії під дією сил гравітації. Виведено аналітичні залежності, що описують процес. Висновки теорії порівнюються з наявними експериментальними знаннями.*

Ключові слова: *обертання зірок, обертання планет, джерело енергії обертання зірок.*

Introduction. Everything in the universe revolves. Stars revolve, planets revolve around stars. Planets rotate around their own axes. Whole galaxies rotate. All objects and systems of the Universe have axial and orbital moments of rotation.

There is no clear explanation of the reasons for the rotation of space systems. There is a widespread argumentation that the rotation in the Universe can be explained by the action of gravitational forces and collapse of molecular clouds into a single point, to which the particles that lead to the rotation of the protocloud aspire [4].

A rotating star, in turn, creates a rotating disk from a protoplanetary gas and dust cloud. Stars rotate on their axis from birth as the gas cloud collapses into the pro-tostar. Momentum is conserved, causing the star to spin out as it forms. Behind everything is the principle of momentum conservation [5].

There are many speculations on the net about this topic. Some of them are summarized below:

- Celestial bodies rotate on their axis by inertia, due to a magnetic field and a given momentum for motion;
- Celestial bodies rotate because they are formed from large clouds of cosmic dust;
- By pure chance, it may be that most of the gas and dust end up "spun" in the same direction;

- The rotation comes from the fact that water in a drainage funnel rotates in a similar way.
- etc.

Problem statement. The form, content and movement of everything around us is formed by energy. Initialization of rotation requires energy expenditure. For cosmic objects with impressive masses, the magnitude of this energy is significant. For the Earth making one revolution per day, it required 7.07e32 joules, equivalent to the explosion of 10e22 bombs dropped on Hiroshima. And to ensure the Earth's rotation in orbit around the Sun required an energy of 2.5138e42 joules, equivalent to 3.632*10e31 of the same bombs. If we imagine the rotational energy of the entire solar system, or other stellar systems, the random occurrence of the rotation of celestial bodies must be ruled out. Random appearance and random energy consumption are not provided by nature.

The increase in the rotational velocity of the star due to the conservation of momentum during the compression of the protoplanetary disk also does not stand up to criticism. Although this hypothesis is the most widely accepted. The momentum, or kinetic momentum, in the system is constant. The energy of the system is constant. The only variable is the speed of rotation depending on the radius of rotation. The random nature of the occurrence of a significant initial moment of momentum in all stellar systems without exception is questionable.

All objects in space have a moment of rotation, which testifies to a single law that causes this phenomenon. The solution of the problem implies, firstly, identification of energy sources for starting the rotation, and secondly, identification of the mechanism of transformation of this energy into an organized rotation of celestial bodies.

Problem Solving. Gas-dust clouds, which are considered to be the cradle of star-planetary systems, are not a fixed substance frozen in space. The appearance of the cloud was preceded by a powerful explosion that threw energy and matter into space. From the high concentration, after some time, the energy was dispersed in the form of chaotically moving particles. The energy took the kinetic form of particle motion.

Due to the large size and random fluctuations in the cloud, the uniform distribution of matter density over the volume was disturbed. The mobility of particles contributed to the random appearance of places of local compaction of matter. Centers of gravitational attraction were formed, causing progressive consolidation of matter clots around the appeared centers.

The appeared center of gravitational attraction (C.G.) starts the process of cloud compression to the center. After some time, the outer boundary of the cloud with diameter D_1 will shrink to the boundary with diameter D_2. After compression, the matter density will increase, while the energy density will remain the same.

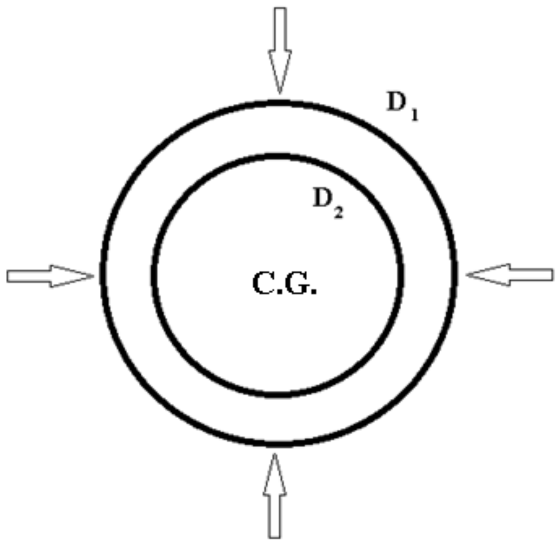

Fig. 1. Schematic of a collapsing gas-dust cloud

Conservation of energy density requires clarification. The physicist Rudolf Clasius was the first to point out this peculiarity of energy in relation to thermodynamics. He argued that in a closed system, energy goes from a high level of concentration to a low level of concentration. Energy dissipates until the difference in energy levels in different parts of the system is eliminated. Energy cannot move in the opposite direction, towards concentration. The energetic equilibrium state of the protodisc was equality of energy density across the entire disk slice

Let us express the kinetic energy density through the specific energy of a unit mass. To calculate the specific energy, it is enough to divide the kinetic energy by the mass. The traditional formula

$$E = \frac{mv^2}{2}$$

takes the form

$$E = \frac{v^2}{2}$$

The specific kinetic energy of the orbit D_1, according to the additivity property, is equal to the sum of specific kinetic energies of all material particles forming the orbit D_1

$$E_{D_1} = \frac{{v_1}^2}{2}\pi D_1,$$

where, v_1 is the summation vector of velocities of particles of orbit D_1

Similarly, the specific kinetic energy of the orbit D_2 is equal to

$$E_{D_2} = \frac{{v_2}^2}{2}\pi D_2,$$

where v_2 is the summation vector of velocities of particles of the orbit D_2. According to the law of conservation

$$E_{D_1} = E_{D_2}$$

$$\frac{{v_1}^2}{2}\pi D_1 = \frac{{v_2}^2}{2}\pi D_2$$

$$\boldsymbol{{v_1}^2 D_1 = {v_2}^2 D_2} \quad (1)$$

Analyzing (1), we note that $\boldsymbol{v_2} > \boldsymbol{v_1}$ since $\boldsymbol{D_1} > \boldsymbol{D_2}$. But the velocities of the particles were equalized at the stage of stabilization of the cloud. How did the particles of orbit D_2 exceed the average steady-state particle velocity in the disk? Where did the extra energy to accelerate these particles come from?

Nature has found a creative solution. How it happens is shown in Fig. 2.

In addition to the averaged velocity vector $\bar{V}_1$, directed toward the center of gravity, there appears a tangential vector $\bar{V}_t$ The vector $\bar{V}_t$ causes twisting of the protodisc. In sum with vector $\bar{V}_1$, vector $\bar{V}_t$ form the twisting of the medium, which before represented chaotically moving particles.

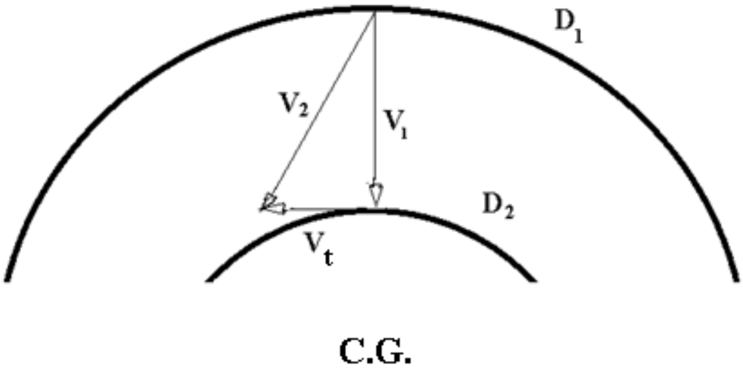

Fig. 2. Schematic of protodisc unwinding

By adding the vector $\bar{V}_1$ with the vector $\bar{V}_t$, the velocity is increased to the value $\bar{V}_2$.

$$\bar{V}_2 = \bar{V}_1 + \bar{V}_t$$

The vector $\bar{V}_t$ is perpendicular to the vector $\bar{V}_1$. The scalar product of perpendicular vectors is zero. And accordingly the work of gravitational force on the increment of velocity is zero. No additional energy was required to increase the velocity of the particles.

The appearance of the tangential vector $\bar{V}_t$ is inevitable. Due to this vector the law of conservation of energy is fulfilled. The energy remained at the same level despite the acceleration of particles relative to the center of gravitation.

The gravitational forces, without changing the energy balance of the system, give rotation to the protodisk. Chaotically moving particles acquire organized rotational motion. The kinetic energy of particle motion was accumulated in the rotational energy of the formed cosmic bodies. The rotational energy of celestial bodies is not taken from somewhere or created. It is borrowed from the energy of motion of individual cloud particles.

Theory testing. Any theory requires testing. We use two methods for this purpose: theoretical and experimental. For theoretical testing, we will use the conclusions of I. Kepler's third law. For experimental verification we use the current knowledge of the solar system.

According to Kepler's third law: the squares of the periods of the orbital revolution of the planets around the Sun are related as the cubes of the major semi-axes of the orbits of the planets.

$$\frac{{T_1}^2}{{T_2}^2} = \frac{{a_1}^3}{{a_2}^3}, \tag{2}$$

where T_1 and T_2 are the orbital periods of the two planets around the Sun, and a_1 and a_2 are the lengths of the major semi-axes of the elliptical orbits of these planets.

Let us rewrite (1) in the form

$$\frac{{v_2}^2}{{v_1}^2} = \frac{D_1}{D_2} \tag{3}$$

The length of the circular orbit **L=πD**. Let's substitute the value **D=L/π** in (3)

$$\frac{{v_2}^2}{{v_1}^2} = \frac{L_1}{L_2}$$

Let us express the orbital velocity v through the orbital extent L and period T

$$\frac{\left(\frac{L_2}{T_2}\right)^2}{\left(\frac{L_1}{T_1}\right)^2} = \frac{L_1}{L_2} \tag{4}$$

Let's solve (4)

$$\frac{{T_1}^2}{{T_2}^2} = \frac{{L_1}^3}{{L_2}^3}.$$

For circular orbits L=2*π*R. Thus

$$\frac{{T_1}^2}{{T_2}^2} = \frac{{R_1}^3}{{R_2}^3}.$$

We have arrived at the expression of Kepler's third law (2) for circular orbits. The theoretical test is passed.

Let us proceed to the experimental verification of the theory. The source of energy of planetary motion was the energy of the rotating protoplanetary disk from which these planets were formed. The specific energy of an orbit corresponds to the product of the specific energy of the planet by the length of the orbit. This energy is the same for all orbits.

$$Const = \frac{(The\ orbital\ velocity\ of\ the\ planet)^2}{2} \pi * D,$$

where D – is the diameter of the orbit.

The results of the calculations are summarized in Table 1.

$$1.0e{+}17 * (m^3/s^2)$$

Table 1

Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune
4.1960	4.1542	4.210	4.1502	4.1731	4.2161	4.0774	4.2203

The results confirm the theory. The specific energies of the orbits are equal to each other. Small deviations, less than 3%, are due to the replacement of elliptical orbits by circular orbits to simplify the calculations.

The compression of the gas-dust cloud leads to the appearance of a massive rotating central body (star) and a rotating proto-planetary disk. In the body of the proto-planetary disk, in turn, planets and their satellites can form. The role of the central body is now performed by the planets, which, similarly to the star, form local protoplanetary disks around themselves, from which the satellites are formed. Most planets in the Solar System have their own subordinate systems.

According to the accepted theory, the specific energies of the orbits of the satellites of the planets are equal.

$$Const = \frac{\left(\frac{\text{Orbital velocity}}{\text{satellite of a planet}}\right)^2}{2} \pi * D,$$

1.0e+17 * (m^3/s^2) Jupiter

Table 2

Io	Europa	Ganymede	Callisto
3.9786	3.9770	3.9786	3.9774

1.0e+17 * (m^3/s^2) Saturn

Table 3

Titan	Enceladus	Mimas	Diona
1.1903	1.1836	1.1879	1.6363

1.0e+16 * (m^3/s^2) Uranus

Table 4

Titania	Oberon	Ariel	Umbriel
3.6278	3.6361	3.6226	3.6431

The specific energies of the satellites' orbits are the same. The value of this energy is individual for each planet. This indicates a different energy density of the region in which the satellites were formed. The homogeneity of the energy density, however, was observed near each planet. We state that the condition for the emergence of gravitational collapse is not only the presence of a centre of attraction, but also the homogeneity of energy density where this process occurs.

The anomalous deflection of Saturn's satellite Dione (Table 3) is probably caused by external factors. The surface of Dione is isobilically mottled with craters. The size of some craters reaches 100 km in diameter. At the same time, the diameter of Dione is ten times smaller than the Earth's.

By transforming expression (1), we can calculate the orbits parameters.

$$\boldsymbol{v_2 = v_1 \sqrt{\frac{D_1}{D_2}}} \qquad (5)$$

For example, given the initial data:

$\boldsymbol{v_1}$ – 24077 m/sec is the orbital velocity of Mars;

$\boldsymbol{D_1}$ – 456e9 m – orbital diameter of Mars;

$\boldsymbol{D_2}$ – 116e9 m – orbital diameter of Mercury;

We can determine Mercury's orbital velocity.

$$v_2 = v_1 \sqrt{\frac{D_1}{D_2}} = 24077\ \mathrm{m/sec}\ \sqrt{\frac{456e9\ m}{116e9\ m}} = 47737\ \mathrm{m}/sek \approx 48\frac{\mathrm{km}}{\mathrm{sec}}$$

The average orbital velocity of Mercury along its orbit is 48 km/s (at aphelion – 38.7 km/s, and at perihelion – 56.6 km/s).

The ratio of the orbital velocities of the planets is inversely proportional to the square root of the ratio of their orbital diameters (lengths).

Let's try to determine the rotation speed of the Sun's surface using formula (5).

Let's use the information:

$\boldsymbol{v_1}$ – 48 km/sec is the orbital velocity of Mercury;

$\boldsymbol{D_1}$ – 116e6 km – diameter of Mercury's orbit;

$\boldsymbol{D_2}$ – 1392700 km – diameter of the Sun;

$$v_2 = v_1 \sqrt{\frac{D_1}{D_2}} = 48\mathrm{km/sec} \sqrt{\frac{116e6\ km}{1392700\ \mathrm{km}}} = 438\ \mathrm{km/sec}$$

The real rotational velocity of the Sun's surface near the equatorial zone is 2.025 km/sec, significantly different from the calculated value of 438 km/sec.

The proponents of the idea of stellar rotation due to the law of conservation of momentum, assume that the observed deceleration of the star occurs due to the interaction of the magnetic field of the protostar with the outflowing wind. The outgoing wind carries away some of the angular momentum and slows down the rotation speed of the future star [1; 2].

Let's specify more reliable, in our opinion, the reason of the Sun's deceleration. The Sun has kinetic energy of rotation. The value of this energy corresponds to the energy of protostellar space, from which the Sun was formed. Let us call this region the protosphere.

We calculate the solar rotation energy by the formula

$$E = \frac{1}{2} J w^2,$$

where $\mathbf{J} = \frac{2mr^2}{5}$ – is the moment of inertia of the ball; $\boldsymbol{w} = \frac{v}{r}$ – is the angular velocity; $\boldsymbol{m}$ – is the mass; v is the rotational velocity; $\boldsymbol{r}$ – is the radius

$$E = \frac{1}{2}\frac{2mr^2}{5}\frac{v^2}{r^2} = \frac{mv^2}{5}$$

Let's introduce notations: $\boldsymbol{m_1}$ – mass of the Sun's protosphere; $\boldsymbol{v_1}$ – rotation speed of the Sun's protosphere 438 km/sec; $\boldsymbol{m_2}$ – mass of the Sun – 1.98e30 kg; $\boldsymbol{v_2}$ – rotation speed of the Sun 2.025e3km/sec.

By virtue of the law of conservation, the rotational energy of the Sun's protosphere and the rotational energy of the modern Sun are the same. Let's write down

$$\frac{m_2 {v_2}^2}{5} = \frac{m_1 {v_1}^2}{5} \tag{6}$$

Having reformatted (6), we obtain the modern rotation speed of the Sun

$$v_2 = \frac{m_1 {v_1}^2}{m_2} = 2.025e3\,\frac{\text{km}}{\text{sec}} \tag{7}$$

Equality (7) is valid if we assume that the mass of the protosphere $\boldsymbol{m_1}$, rotating at a speed of 438 km/sec, was much smaller than the present-day $\boldsymbol{m_2}$ mass of the Sun (1.98e30 kg). By transforming equality (7), we can predict the historical mass of the Sun's protosphere

$$m_1 = \frac{m_2 {v_2}^2}{{v_1}^2}$$

$$m_1 = \frac{1.98e30kg\ (2.025e3\ \frac{m}{sec})^2}{(438e3\ \frac{m}{sec})^2} = 9.154e27\ \text{kg}$$

The density of the Sun's protosphere was

$$Ro = \frac{m_1}{V} = \frac{9.154e27\ \text{kg}}{7.9516e26\ \text{m}^3} = 11.5121\ \frac{\text{kg}}{\text{м}^3},$$

where V is 7.9516e26 m^3 (the internal volume of the Sun).

The density of the Sun's protosphere was almost 10 times the density of air (1.2041 kg/m^3).

The calculated parameters of the protosphere of the Sun, fix the starting state of the nascent star. From this moment, the rotation of the Sun is no longer related to the rotation of the protodisk. The Sun's rotation continues by inertia, independent of the rotation of the protodisk. But gravitational collapse is not yet complete, and accretion of the Sun is continuing. The mass of the Sun grows and its rotation speed, according to expression (7), slows down. The mass gain is completed when the Sun reaches a mass of 1.98e30 kg, which corresponds to the first cosmic velocity of the Sun – 437.047 km/sec. This speed practically coincides with the rotation speed of the Sun's protosphere – 438 km/sec.

Stars are not solids, so there may be a velocity gradient between the initially faster core and the slower outer layers. Astronomers from the University of California at Los Angeles found that the inner layers and core of the Sun rotate four times faster than its surface [3].

Let us check the discovered regularity on the satellites of planets. Let us use the same formula (5). Now $\boldsymbol{v_2}$ – is the rotation velocity of the planet protosphere; $\boldsymbol{v_1}$ – is the orbital velocity of the planet satellite; $\boldsymbol{D_1}$ – is the orbital diameter of the planet satellite; $\boldsymbol{D_2}$ – is the diameter of the planet. For example, consider the satellite Io of the planet Jupiter.

$$v_2 = v_1 \sqrt{\frac{D_1}{D_2}} = 17.334e3\ \frac{km}{sec} \sqrt{\frac{2*421700\ km}{139820\ km}} = 42.56\ \frac{km}{sec}$$

The real first space velocity of Jupiter is 42.58 km/sec. We have a practical coincidence with the calculated value.

Let's anchor our findings on a number of planets in the solar system.

Table 5

Planet	**Diameter planets** D_2 km	**The first cosmic velocity of the planet** $v\ km/sec$	**The velocity of the planet's protosphere** $v_2\ km/sec$	**Satellite**	**Orbital velocity of the satellite** $v_1\ km/sec$	**Satellite orbit diamete** D_1 km
Earth	12742	7.91	7.95	Moon	1.023	770000
Mars	6779	3.55	10.36	Deimos	3.94	46916
			3.62	Phobos	2.18	18740
Jupiter	139820	42.58	42.57	Europa	13.74	1342000
Saturn	116460	25.53	25.52	Titan	5.57	2443740
			42.23	Dione	16.59	754800
Neptune	49244	16.66	16.65	Triton	4.388	709500

Non-observance of the regularity was found only for the Moon, the Mars satellites Deimos and Phobos, and the Saturn satellite Dione. In all other cases, the velocities of the protospheres of the planets coincided with the first space velocity of these planets.

The first cosmic velocity is equal to.

$$v = \sqrt{\frac{GM}{r}}$$

where $\boldsymbol{G}$=6.6743×10^{-11} m^3 kg^{-1} sec^{-2} is the gravitational constant; M is the mass of the body; r is the radius of the body.

This velocity is equal to the velocity of the planet's protosphere

$$\sqrt{\frac{GM}{r}} = v_1 \sqrt{\frac{D_1}{D_2}}$$

Since $D_2 = 2r$, we have

$$\boldsymbol{2GM = v_1{}^2 D_1} \qquad (8)$$

The universal dependence (8) defines the relation between the center of gravity and orbital parameters. The versatility of its application will be shown by examples.

Example 1. The orbital velocity of Venus $\boldsymbol{v_1}$=35 km/sec and the diameter of its orbit $\boldsymbol{D_1}$ =216e6 km are known. What is the mass of the Sun?

$$\boldsymbol{M} = \frac{{v_1}^2 D_1}{2G} = \frac{(35000\frac{m}{sec})^2 216e9\, m}{2 * 6.6743e - 11\ \mathrm{m}^3 kg^{-1} sec^{-2}} = 1.9823e30\ kg$$

In fact, the Sun's mass is 1.989e30 kilograms.

Example 2. The mass of Jupiter M=1.89e27 kg. is known, $\boldsymbol{v_1}$ is the orbital velocity of the satellite Io=17.334 km/sec. What is the orbital diameter of the satellite Io ?

$$\boldsymbol{D_1} = \frac{\boldsymbol{2GM}}{\boldsymbol{{v_1}^2}} = \frac{2*6.6743e-11\, m^3 kg^{-1} sec^{-2} * 1.89e27\ \mathrm{kg}}{(17334\, m/sec)^2} = 839600e3\ \mathrm{m}$$

In fact, the diameter of Io's orbit is 843400e3 meters.

Example 3. The mass of the Sun M=1.989e30 kg is known. The orbital velocity of the Earth is known $\boldsymbol{v_1}$ = 29.72 km/sec The diameter of the Earth's orbit is known $\boldsymbol{D_1}$= 296e6 km. What is the value of the gravitational constant $\boldsymbol{G}$?

$$\boldsymbol{G} = \frac{{v_1}^2 D_1}{2M} = \frac{\left(29720\frac{m}{sec}\right)^2 * 296e9m}{2*1.989e30\ \mathrm{kg}} = 6.5724e - 11\ \mathrm{m}^3\ \mathrm{kg}^{-1}\ \mathrm{s}^{-2}$$

In fact, G= 6.6743×10^{-11} m^3 kg^{-1} sec^{-2}

Note. To simplify calculations, elliptical orbits were replaced by circular orbits.

Conclusions. The rotation of the gas-dust cloud began due to the appearance of a tangential velocity vector perpendicular to the gravitational attraction vector. Because of the perpendicularity of the vectors, the work of the gravitational force to increase the velocity is zero. No additional energy was required to accelerate the particles. Due to the tangential vector, the law of conservation of energy was observed.

The kinetic energy of motion of individual particles was summed up into the organized rotation of the resulting cosmic bodies.

There comes a stage in the formation of cosmic bodies when their rotation becomes independent of the rotation of the parent proto-cloud.

Gravitational collapse is not yet complete and the accretion of the cosmic body continues.

The slowing down of the Sun's rotation occurred due to an increase in its mass against the background of independent continuing rotation by inertia.

The accretion limit is the mass of the body at which the first cosmic velocity reaches the rotational velocity of the parent proto-cloud.

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